

ANNEX G

Methodology for Estimating CH₄ Emissions from Petroleum Systems

The methodology for estimating methane emissions from petroleum systems is based on the 1999 EPA draft report, *Estimates of Methane Emissions from the U.S. Oil Industry* (EPA 1999) and Radian's Study, *Methane Emissions from the U.S. Petroleum Industry* (Radian 1996). Seventy activities that emit methane from petroleum systems were examined for these reports. Most of the activities analyzed involve crude oil production field operations, which accounted for 97 percent of total oil industry emissions. Crude transportation and refining accounted for the remaining emissions at about one and two percent each, respectively.

The following steps were taken to estimate methane emissions from petroleum systems.

Step 1: Determine Emission Factors for all activities

The emission factors for 1995 are taken from the 1999 EPA draft report, which contains the most recent and comprehensive determination of emission factors for the seventy methane emitting activities in the oil industry. The emission factors determined for 1995 are assumed to be representative of emissions from each source type over the period 1990 through 2000. Therefore, the same emission factors are used for each year throughout this period.

Step 2: Determine Activity Levels for Each Year

Activity levels change from year to year. Some factors change in proportion to crude oil rates: production, transportation, or refinery runs. Some change in proportion to the number of facilities: oil wells or petroleum refineries. Some factors change proportional to both rate and number of facilities.

For fifty-seven of the seventy activities, activity levels for 1995 are taken from EPA. For the remaining thirteen activities, the activity level for 1993 is taken from Radian (1996). These thirteen activity levels were derived from field data collected in 1993, along with 1993 crude oil production and number of wells.

For both sets of data, a determination was made on a case-by-case basis, as to which measure of petroleum industry activity best reflects the change in annual activity relative to the base years (1993 and 1995). Publicly reported data from the Minerals Management Service (MMS), Energy Information Administration (EIA), American Petroleum Institute (API) and the Oil & Gas Journal (O&GJ) were used to extrapolate the activity levels from the base year to each year between 1990 to 2000. Data used include total domestic crude oil production, number of domestic crude oil wells, total imports and exports of crude oil, and total petroleum refinery crude runs. For a small number of sources, 2000 data were not yet available. In these cases, the 2000 activity factors were used. In the few cases where no data was located, activity data based on oil industry expert judgment were used.

Step 3: Estimate Methane Emissions for Each Activity for Each Year

Annual emissions from each of the 70 petroleum system activities analyzed were estimated by multiplying the activity data for each year by the corresponding emission factor. These annual emissions for each activity are then summed to estimate the total annual methane emissions. Table G-1, Table G-2, and Table G-3 provide the 2000 activity factors, emission factors, and emission estimates.

Table G-4 provides a summary of emission estimates for the years 1990 through 2000.

Table 6-1: 2000 CH₄ Emissions from Petroleum Production Field Operations

Activity/Equipment	Emission Factor	Units	Activity Factor	Units	Emissions (Bcf/yr)
Vented Emissions					
Oil Tanks	18 scf of CH ₄ /lbl crude		1,234	MMbbl/yr (non stripper wells)	47.754
Pneumatic Devices, High Bleed	345 scfd CH ₄ /device		142,840	No. of high-bleed devices	22.086
Pneumatic Devices, Low Bleed	35 scfd CH ₄ /device		265,275	No. of low-bleed devices	17.998
Chemical Injection Pumps	248 scfd CH ₄ /pump		28,595	No. of pumps	3,342
Vessel Blowdowns	78 scfy CH ₄ /vessel		186,502	No. of vessels	2,589
Compressor Blowdowns	3,775 scflyr of CH ₄ /compressor		2,531	No. of compressors	0.015
Compressor Starts	8,443 scflyr. of CH ₄ /compressor		2,531	No. of compressors	0.010
Stripper wells	2,345 scflyr of CH ₄ /stripper well		348,867	No. of stripper wells vented	0.021
Well Completion Venting	733 scf completion		4,731	Oil well completions	0.818
Well Workovers	96 scf CH ₄ /workover		40,050	Oil well workovers	0.003
Pipeline Pigging	2.40 scfd of CH ₄ /pig station		0	No. of crude pig stations	0.004
Offshore Platforms, Gulf of Mexico	1,283 scfd CH ₄ /platform		1,832	No. of oil platforms	0.000
Offshore Platforms, Other U.S. Areas	1,283 scfd CH ₄ /platform		23	No. of oil platforms	0.011
Fugitive Emissions					
Offshore Platforms, Gulf of Mexico	56 scfd CH ₄ /platform		1,832	No. of oil platforms	2.476
Offshore Platforms, Other U.S. Areas	56 scfd CH ₄ /platform		23	No. of oil platforms	0.037
Oil Wellheads (heavy crude)	0.13 scfd/well		13,052	No. of hvy. crude wells *	0.000
Oil Wellheads (light crude)	16.6 scfd/well		172,081	No. of lt. crude wells *	0.001
Separators (heavy crude)	0.15 scfd CH ₄ /separator		10,970	No. of hvy. crude sep.	1.045
Separators (light crude)	14 scfd CH ₄ /separator		99,837	No. of lt. crude sep.	0.001
Heater/Treaters (light crude)	19 scfd CH ₄ /heater		75,695	No. of heater treatrs	0.505
Headers (heavy crude)	0.08 scfd CH ₄ /header		13,929	No. of hvy. crude hrs.	0.530
Headers (light crude)	11 scfd CH ₄ /header		43,183	No. of lt. crude hrs.	0.000
Floating Roof Tanks	338,306 scf CH ₄ /floating roof tank/yr.		24	No. of floating roof tanks	0.171
Compressors	100 scfd CH ₄ /compressor		2,531	No. of compressors	0.008
Large Compressors	16,360 scfd CH ₄ /compressor		0	No. of large comprs.	0.092
Sales Areas	41 scf CH ₄ /loading		1,760,539 Loadings/year	0.000	0.000
Pipelines	0 scfd of CH ₄ /mile of pipeline		30,467 Miles of gathering line	0.071	0.000
Well Drilling	0 scfd of CH ₄ /oil well drilled		7,437 No. of oil wells drilled	0.000	0.000
Battery Pumps	0.24 scfd of CH ₄ /pump		160,200 No. of battery pumps	0.014	0.014

Combustion Emissions				1.630
Gas Engines	0.08 scf CH ₄ /HP-hr	15,945 MMHP-hr		1.276
Heaters	0.52 scf CH ₄ /bbl	2113.0 MBbbl/yr		0.001
Well Drilling	2,453 scf CH ₄ /well drilled	7,437 Oil wells drilled, 1995		0.018
Flares	20 scf CH ₄ /per Mcf flared	485,883 Mcf flared/yr		0.010
Offshore Platforms, Gulf of Mexico	481 scfd CH ₄ /platform	1,832 No. of oil platforms		0.321
Offshore Platforms, Other U.S. Areas	481 scfd CH ₄ /platform	23 No. of oil platforms		0.004
Process Upset Emissions				0.548
Platform Emergency Shutdowns	256,888 scfy/yr/Platform	1,855 No. of platforms		0.477
Pressure Relief Valves	35 scfy/yr/PR valve	176,498 No. of PR valves		0.006
Well Blowouts Offshore	5.0 MMscf/blowout	2.25 No. of blowouts/yr		0.011
Well Blowouts Onshore	2.5 MMscf/blowout	24.8 No. of blowouts/yr		0.062
Total (excluding stripper wells)				52.42

Table G-2: 2000 CH₄ Emissions from Petroleum Transportation

Activity/Equipment	Emission Factor	Units	Activity Factor	Units	Emissions (Bcf/yr)
Vented Emissions					0.233
Tanks	0.021 scf CH ₄ /yr/bbl of crude delivered to refineries		5,514 MMbbl crude feed/yr		0.114
Truck Loading	0.520 scf CH ₄ /yr/bbl of crude transported by truck		50.6 MMbbl crude feed/yr		0.026
Marine Loading	2,544 scf CH ₄ /1000 gal. crude marine loadings		29,581,881 1,000 gal./yr loaded		0.075
Rail Loading	0.520 scf CH ₄ /yr/bbl of crude transported by rail		7.3 MMbbl. Crude by rail/yr		0.004
Pump Station Maintenance	36.80 scf CH ₄ /station/yr		490 No. of pump stations		0.000
Pipeline Pigging	39 scfid of CH ₄ /pig station		980 No. of pig stations		0.014
Fugitive Emissions					0.050
Pump Stations	25 scf CH ₄ /mile/yr.		48,990 No. of miles of crude pl		0.001
Pipelines	0 scf CH ₄ /bbl crude transported by pipeline		7,551 MM bbl crude piped		0.000
Floating Roof Tanks	58,965 scf CH ₄ /floating roof tank/yr.		824 No. of floating roof tanks		0.049
Combustion Emissions					0.000
Pump Engine Drivers	0.24 scf CH ₄ /hp-hr		NA No. of hp-hrs		NA
Heaters	0.521 scf CH ₄ /bbl burned		NA No. of bbl Burned		NA
Total					0.283

Table G-3: 2000 CH₄ Emissions from Petroleum Refining

Activity/Equipment	Emission Factor	Units	Activity Factor	Units	Emissions (Bcf/yr)
Vented Emissions					
Tanks	20.6 scfCH ₄ /Mbbi				1,260
System Blowdowns	137 scfCH ₄ /Mbbi				0.015
Asphalt Blowing	2,555 scfCH ₄ /Mbbi				0.754
Fugitive Emissions					
Fuel Gas System	439 McfCH ₄ /refinery/yr.				0.093
Floating Roof Tanks	587 scf CH ₄ /floating roof tank/yr.				0.069
Wastewater Treating	1.88 scfCH ₄ /Mbbi				0.000
Cooling Towers	2.36 scfCH ₄ /Mbbi				0.010
Combustion Emissions					
Atmospheric Distillation	3.61 scfCH ₄ /Mbbi				0.013
Vacuum Distillation	3.61 scfCH ₄ /Mbbi				0.092
Thermal Operations	6.02 scfCH ₄ /Mbbi				0.020
Catalytic Cracking	5.17 scfCH ₄ /Mbbi				0.009
Catalytic Reforming	7.22 scfCH ₄ /Mbbi				0.004
Catalytic Hydrocracking	7.22 scfCH ₄ /Mbbi				0.010
Hydrorefining	2.17 scfCH ₄ /Mbbi				0.009
Hydrotreating	6.50 scfCH ₄ /Mbbi				0.004
Alkylation/Polymerization	12.6 scfCH ₄ /Mbbi				0.001
Aromatics/Isomerization	1.80 scfCH ₄ /Mbbi				0.000
Lube Oil Processing	0.00 scfCH ₄ /Mbbi				0.000
Engines	0.006 scfCH ₄ /hp-hr				0.008
Flares	0.189 scfCH ₄ /Mbbi				0.001
Total					1.445

Table G-4: Summary of CH₄ Emissions from Petroleum Systems (Bcf)

Activity	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
Production Field Operations	1,227	1,245	1,201	1,159	1,139	1,122	1,114	1,112	1,081	1,028	1,008
Tank venting	564	570	548	519	502	493	485	484	466	433	425
Pneumatic device venting	525	535	517	507	504	497	496	495	485	470	460
Wellhead fugitives	25	26	25	24	25	25	25	24	23	21	20
Combustion & process upsets	47	48	46	45	45	44	45	45	44	42	42
Misc. venting & fugitives	66	66	65	64	64	63	63	63	62	61	61
Crude Oil Transportation	7	6	6	6	6	6	6	6	6	6	5
Refining	25	24	24	25	25	25	26	27	27	27	28
Total	1,258	1,276	1,231	1,190	1,170	1,154	1,145	1,144	1,114	1,061	1,041

Note: Totals may not sum due to independent rounding.